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WATER QUALITY IN THE TEXAS COASTAL BASINS

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Agricultural Research Service
 UNITED STATES DEPARTMENT OF AGRICULTURE
 in cooperation with
 Oklahoma Agricultural Experiment Station

WATER QUALITY IN THE TEXAS COASTAL BASINS

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ABSTRACT

Ten years of water-quality records were examined to evaluate the usability of water in the Texas coastal basins, particularly for agriculture, and to determine if agriculture was affecting water quality. Average values of 7 water-quality parameters in 2 periods (1964-69 and 1969-74) were calculated for 23 rivers and basins. The quality of water for agricultural use decreased from the northeast to the southwest. The low quality of water in some basins requires special management for use. Nitrate concentrations were examined in relation to streamflow, seasons, land use, and years. The evidence did not indicate that agricultural activities were seriously degrading the stream water. **KEYWORDS:** gulf coast water basins, irrigation, nitrates, Texas water basins, water analysis, water basins, water flow.

INTRODUCTION

An evaluation of the water quality in the Texas coastal basins was conducted as part of a cooperative river-basin survey under the direction of the Soil Conservation Service of the U.S. Department of Agriculture. The two objectives of the study were: (1) to evaluate the water for use, particularly for agriculture, and (2) to evaluate the impact of agriculture on water quality. Records of chemical analyses from the stations in the study area were obtained from the reports of the U.S. Geological Survey (6).² Comparison of average values with water-quality standards was used to achieve the first objective. The data were divided into two periods, 1964-69 and 1969-74, to determine changes with time. The changes in nitrate (NO_3) concentrations with streamflow, years, season, and amount of cropland were used to evaluate the impact of agriculture.

The study area (fig. 1) is a strip along the Texas gulf coast about 70 mi wide and 400 mi long, including the Houston metropolitan area. The average annual rainfall varies from 54 in on the northeast side to 22 in on the southwest side. A humid region can be expected to have an abundance of good quality water; a semiarid region can be expected to suffer from a lack of water and have poorer quality water.

QUALITY OF WATER FOR USE

The study area was divided into 17 river and coastal basins (fig. 2). Data from all stations on small streams in each basin were composited, and an average was computed for stations on each of the 10 major rivers (fig. 2). Data were lacking for three river basins—the Brazos, the Colorado, and the Guadalupe—and the Nueces-Rio Grande coastal basin.

Whenever possible, flow-weighted or time-averaged means of water-quality parameters were computed, but often only arithmetic averages could be calculated. The individual values of the parameters varied greatly with time and location, so that standard deviations were often as large as the means. The statistical

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² Italic numbers in parentheses refer to items in "Literature Cited" at the end of this publication.

TABLE 1.—*Water quality in rivers and basins of the Texas gulf coast*

River or basin	Period	No. of—		Parameter ¹							
		Stations	Samples	EC (μ mho/cm)	SAR ² (meq/l)	Class ³	Cl (mg/l)	TDS (mg/l)	BOD (mg/l)	NO ₃ (mg/l)	PO ₄ (mg/l)
Neches River	1964-69	1	148	192	1.5	C1	28	108	1.5	0.5	0.07
Do	1969-74	1	65	156	1.2	C1	21	88	1.6	.8	.21
Neches basin	1964-69	2	138	222	1.65	C1	47	122	(⁴)	1.0	(⁴)
Do	1969-74	2	97	143	1.3	C1	27	76	(⁴)	1.7	(⁴)
Neches-Trinity coastal basin	1964-69	4	40	559	2.5	C2	93	309	7.0	1.8	.7
Do	1969-74	2	18	693	2.5	C2	122	370	5.2	.7	6.6
Trinity River	1964-69	1	209	515	2.1	C2	60	297	3.2	4.6	1.1
Do	1969-74	2	68	378	1.1	C2	30	110	2.1	3.0	1.6
Trinity basin	1964-69	6	184	554	4.0	C2	94	307	2.3	1.47	.05
Do	1969-74	4	58	171	.9	C1	27	95	(⁴)	.8	(⁴)
Trinity-San Jacinto coastal basin.	1964-69	1	10	530	2.7	C2	56	291	2.8	2.6	2.4
San Jacinto River	1964-69	1	205	314	1.3	C2	50	171	1.9	.50	.23
Do	1969-74	2	71	258	1.3	C2	44	140	2.0	.83	.40
San Jacinto basin	1964-69	7	121	536	1.6	C2	54	292	8.6	1.52	7.8
Do	1969-74	6	19	363	1.8	C2	62	202	4.1	1.6	1.9
San Jacinto-Brazos coastal basin.	1964-69	9	88	759	3.57	C3	91	413	7.7	.67	(⁴)
Brazos River	1964-69	1	202	1,193	3.2	C3	236	391	2.9	1.4	.11
Do	1969-74	2	107	678	2.1	C2	96	374	2.6	3.0	1.1
Brazos-Colorado coastal basin.	1964-69	2	13	757	1.23	C3	158	449	4.6	1.4	(⁴)
Colorado River	1964-69	1	95	508	1.0	C2	45	321	2.7	.9	.33
Do	1969-74	2	59	503	.9	C2	47	276	2.4	2.1	.85
Colorado-Lavaca coastal basin.	1964-69	4	49	893	2.4	C3	140	498	3.3	.3	(⁴)
Do	1969-74	4	46	711	2.1	C2	104	399	3.6	1.8	.73
Lavaca River	1964-69	1	13	629	1.6	C2	67	162	(⁴)	1.4	(⁴)
Do	1969-74	1	56	1,246	1.4	C3	56	348	2.8	1.8	.48
Lavaca basin	1964-69	1	341	554	1.8	C2	69	343	2.21	.6	.07
Navidad River	1969-74	1	160	268	.9	C2	26	153	2.3	2.1	.41
Lavaca-Guadalupe coastal basin.	1964-69	1	10	497	1.6	C2	56	289	2.18	.1	(⁴)
Do	1969-74	3	50	1,838	4.1	C3	418	1,051	2.9	1.2	1.0
Guadalupe River	1964-69	1	170	486	2.3	C2	33	511	1.47	2.9	.26
Do	1969-74	4	67	562	.9	C2	44	323	1.6	4.6	1.0
San Antonio River	1964-69	1	237	1,026	2.1	C3	101	575	2.7	7.3	3.5
Do	1969-74	1	151	862	2.0	C3	109	577	2.4	14.4	4.6
San Antonio basin	1964-69	1	11	1,192	3.0	C3	134	779	1.6	1.3	(⁴)
San Antonio-Nueces coastal basin.	1964-69	3	340	12,450	20.3	C4	5,078	8,086	3.2	2.8	.28

Do	1969-74	2	93	3,456	6.1	C4	1,075	1,008	2.7	1.2	.32
Nueces River	1964-69	1	19	696	1.6	C2	98	424	2.8	1.3	.45
Do	1969-74	1	70	596	1.6	C2	72	343	(⁴)	.84	(⁴)
Nueces basin	1964-69	1	49	947	4.1	C3	128	530	(⁴)	2.4	(⁴)

EC = electrical conductivity (specific conductance); SAR = sodium adsorption ratio; Cl = chloride; TDS = total dissolved solids; BOD = biological oxygen demand; NO₃ = nitrate; PO₄ = phosphate.
² Na/[(Ca + Mg) / 2]^{1/2}.
³ Cl = EC < 250; C2 = 250 < EC < 750; C3 = 750 < EC < 2,250; C4 = EC > 2,250.
⁴ No measurement available.

distribution of the parameters was often skewed because the mean was close to the lower bound of zero. These limitations restricted the use of the averages to first approximations.

The average values of 7 water-quality parameters for 2 periods are given in table 1 for the 23 rivers and basins. Also included are the numbers of stations and samples used to calculate the averages. The number of samples analyzed for biological oxygen demand (BOD) and phosphate (PO₄) was usually less than for the other parameters, and sometimes no measurements were available.



FIGURE 1.—Texas coastal basins study area.

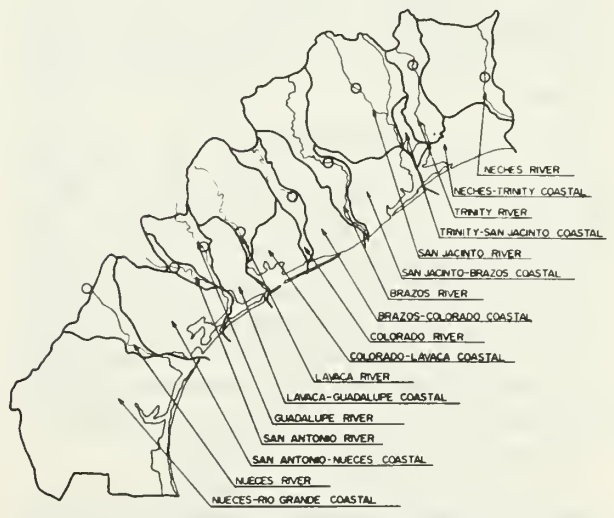


FIGURE 2.—The 17 Texas coastal basins.

The electrical conductivity (EC), or specific conductance, and the sodium adsorption ratio (SAR) are the two parameters most commonly used to classify waters for irrigation (7). As the salinity increases, the value of the SAR permitted for a low sodium (Na) hazard is reduced. Only one basin, the San Antonio-Nueces coastal basin, had any significant Na hazard. However, the high Na values in this basin were caused by the Mission River, which was apparently contaminated by oilfield brine. The high EC, chloride (Cl), and total dissolved solids (TDS) all indicated this problem. Decreases in these values probably reflected efforts to control this contamination.

The salinity hazard (7) of the water for irrigation is given in the column headed "class." Class 1 water is low in salinity and has no limitations for irrigation. Medium-salinity water (C2) could be used if a moderate amount of leaching occurs and plants with moderate salt tolerance are grown. The use of high-salinity water (C3) requires special management with adequate drainage and salt-tolerant crops. Water very high in salinity (C4) is unsuitable for irrigation under ordinary conditions.

As expected, the irrigation quality of water decreased from the humid region to the semi-arid region. Class 2 water from the Trinity is used to irrigate rice, and the waters of the Colorado, Guadalupe, and Nueces are of similar quality. The C3 waters of the coastal basins indicated that salinity problems will probably be encountered if this water is used for irrigation. In addition, the salinity may reflect the saline nature of some soils, which will have salinity problems even if better quality water is used.

The 1972 Water Quality Criteria (1) recommends a limit of 250 mg/l (or parts per million) Cl, and the 1962 Drinking Water Standards of the Public Health Service (3) recommends a limit of 500 mg/l TDS for public water supplies. The Cl recommended was exceeded in the contaminated San Antonio-Nueces coastal basin and recently in the Lavaca-Guadalupe coastal basin. The TDS recommended limit was frequently exceeded in the water south of the Lavaca-Guadalupe coastal basin.

Both NO_3 and PO_4 are nutrient forms important to water quality. A level of 45 mg/l NO_3 in the water is set as a public health

standard and is never approached by the averages in table 1. A more common problem, caused by high concentrations of nutrients, is accelerated eutrophication or excessive growth of aquatic vegetation (2). This problem occurs more often in water impoundments than in flowing streams. There is no agreement on critical concentrations of NO_3 and PO_4 for excessive growth. Nitrate concentrations greater than 1 mg/l are usually considered sufficient for eutrophication. A soluble PO_4 concentration of 0.03 mg/l is a commonly used limit. As a result of the analytical procedure used, the PO_4 concentrations reported represent more than the soluble form. They include some PO_4 from organic and mineral colloids in the water. The fraction of this PO_4 available for growth is not known, but it seems that most of the concentrations were sufficiently high so that PO_4 would not be a limiting nutrient.

Pesticides in water can also limit its use. Herbicides and insecticides have been detected occasionally in most of the streams in the study area, but concentrations are seldom high enough to pose a hazard, except in the Houston metropolitan area. In a recent U.S. Geological Survey study (4), most of the samples with pesticide concentrations greater than recommended environmental levels were from streams in urban areas. Many pesticides are adsorbed on sediment, and the sediment samples analyzed consistently showed the presence of some pesticides (5). The kinds and amounts of these pesticides are not usually a hazard in the water used by agriculture. They are normally removed with the sediment in the treatment of water for industrial or municipal use.

In summary, the quality of the water decreased from the northeast side of the study area to the southwest side, both for domestic use and agricultural use. The waters sampled in the San Antonio-Nueces coastal basin were severely contaminated, possibly by oilfield brine. Although the low water quality in some of the basins was not sufficient to eliminate its use, it was low enough to require special management.

IMPACT OF AGRICULTURE

Farmers can degrade the quality of water in streams by allowing runoff of sediment and agricultural chemicals, especially various pesti-

cides and the plant nutrients nitrogen (N) and phosphorus (P). Pesticide concentrations were low, requiring sophisticated analytical procedures for measurement. Not many samples were analyzed for pesticides until 1969, and the information available is therefore limited. Some persistent pesticides of low toxicity were found in the sediments from all the streams, but the concentrations in the water from non-urban watersheds were high enough to be detected only occasionally.

Phosphate, the most common P form, is distributed between the sediment and solution phases. Usually, a thousand times more PO_4 is present on sediment than in an equal weight of water, and only a small percentage of the PO_4 on the sediment is readily available to plants like algae. Presently, no way exists to determine what fraction is available, and so total PO_4 is usually measured.

Only one station, at Romayor on the Trinity River, had a sufficient number of PO_4 analyses for evaluation. The Trinity receives sewage from Dallas and Fort Worth and many other municipalities, so that the phosphate content could not be used to evaluate the impact of agriculture.

Nitrate is the N form commonly measured in water analyses. Nitrate is not adsorbed on sediment, and its concentrations in water are high enough to be measured by relatively simple chemical methods. Stations on 10 streams had sufficient records to permit evaluation (table 2).

A plot of the NO_3 concentration versus the

TABLE 2.—Water-quality stations used in nitrate evaluation

U.S. Geological Survey station number	Location	River
08041000	Evadale	Neches
08066200	Livingston	Long King ¹
08066500	Romayor	Trinity
08068000	Conroe	San Jacinto
08114000	Richmond	Brazos
08162000	Wharton	Colorado
08164500	Ganado	Navidad
08176500	Victoria	Guadalupe
08188500	Goliad	San Antonio
08189500	Refugio	Mission ²

¹ Located in the Trinity River basin.

² Located in the San Antonio-Nueces coastal basin.

riverflow rate gives a broad envelope of points for all stations. The 1970-74 data for the San Jacinto River are shown in figure 3. The range of flows for each river was divided into four classes containing equal numbers of observations, and the median (50 percentile) concentrations in each class was determined. A plot of this median concentration versus the stream-flow-class midpoint gives a greatly simplified picture for evaluation.

To detect any changes of water quality with time, the data for each stream were aggregated into three periods. Based on standard water

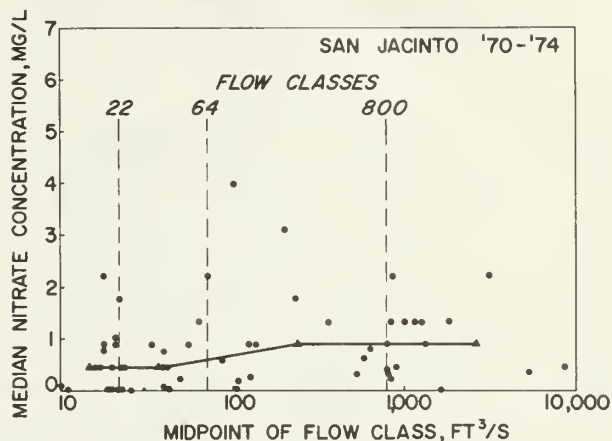


FIGURE 3.—Nitrate concentrations in samples taken at different streamflows, San Jacinto River, 1970-74. The solid line connects the median concentration at the midpoint of each flow class.

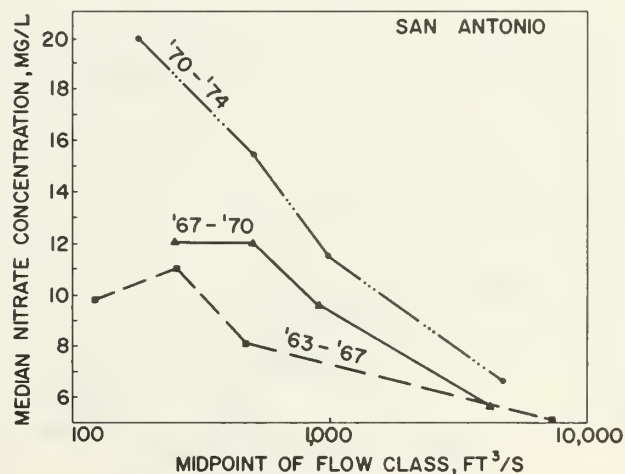


FIGURE 4.—Median nitrate concentration in the San Antonio River with increasing streamflow, for three periods.

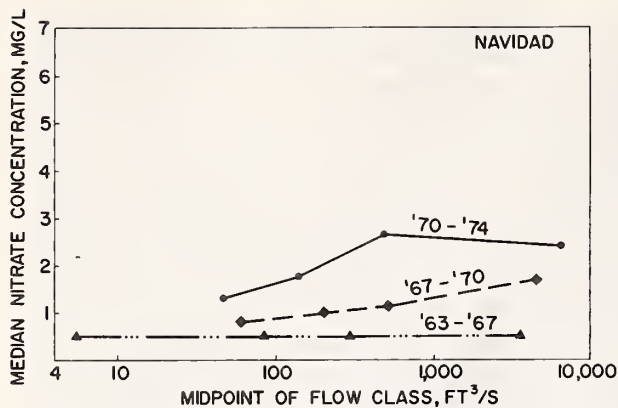


FIGURE 5.—Median nitrate concentration in the Navidad River with increasing streamflow, for three periods.

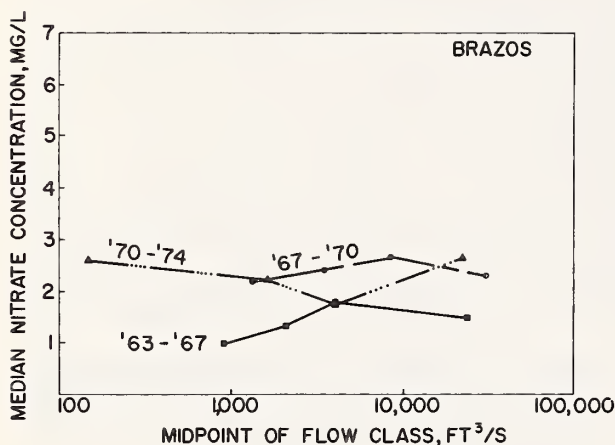


FIGURE 6.—Median nitrate concentration in the Brazos River with increasing streamflow, for three periods.

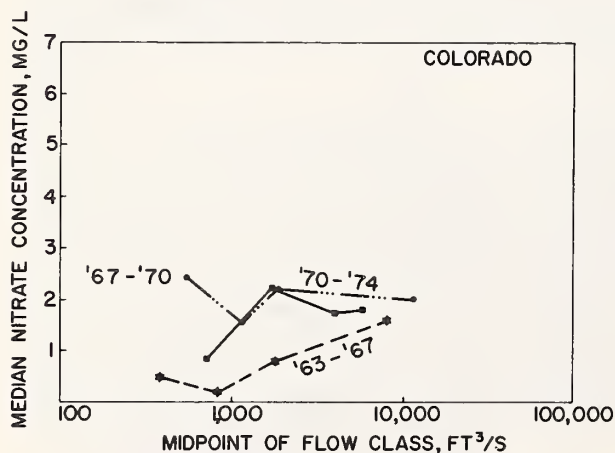


FIGURE 7.—Median nitrate concentration in the Colorado River with increasing streamflow, for three periods.

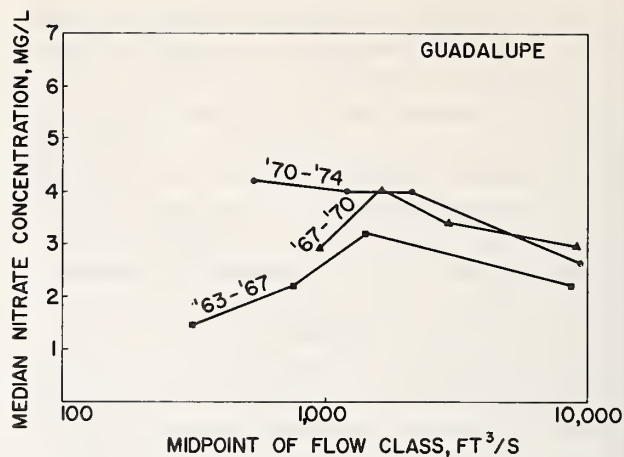


FIGURE 8.—Median nitrate concentration in the Guadalupe River with increasing streamflow, for three periods.

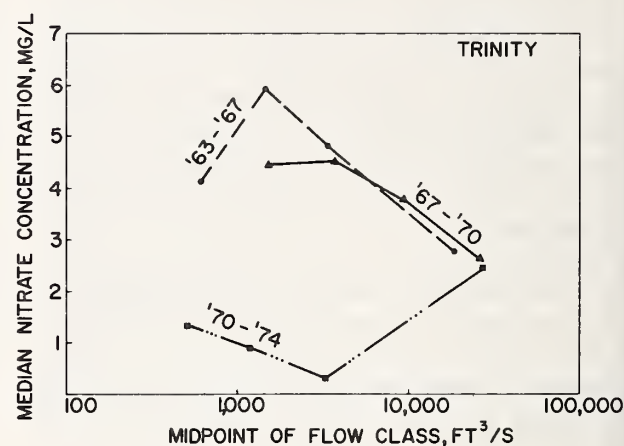


FIGURE 9.—Median nitrate concentration in the Trinity River with increasing streamflow, for three periods.

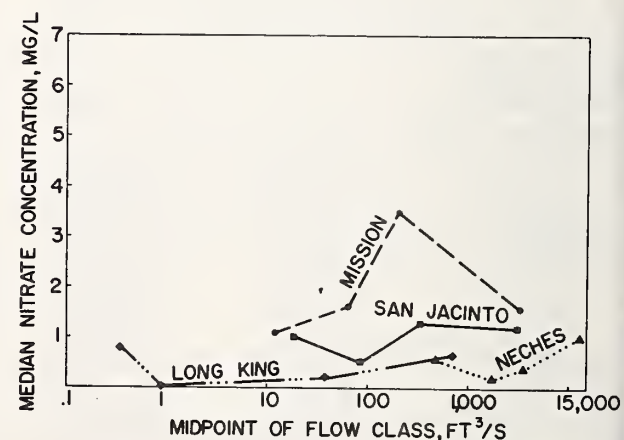


FIGURE 10.—Median nitrate concentration at different streamflows for four rivers.

years of October to September, these periods were: 1963-67, 1967-70, and 1970-74.

Various relations are found among the 10 streams. Data for the San Antonio River (fig. 4) are a good example of dilution. For a constant source, like the municipal effluent from San Antonio, increasing streamflow reduces the concentration. The separate lines illustrate a trend of increasing NO_3 concentration with time, probably associated with increasing population. The range of median concentrations was 10 to 20 mg/l at the high end and 5 to 7 mg/l at the low end.

Data for the Navidad River (fig. 5) showed a different behavior. The concentration did not decrease with flow, but remained relatively constant or increased. This behavior suggests nonpoint sources, like agricultural land. In fact, there are no large centers of population above the measuring station. Concentrations also increased with time, but to a lesser degree.

The data for the Brazos, Colorado, and Guadalupe Rivers (figs. 6-8) indicated a trend for increasing concentrations with time, ranging from 1 to 4 mg/l, but no discernible trends with flow. The data for the Trinity River (fig. 9) showed a possible trend of decreasing concentration with time, with the most recent concentrations ranging from 1 to 3 mg/l. The low NO_3 concentrations might indicate improved sewage treatment or increased use by organisms in the river or both.

Data presented for four rivers (fig. 10) showed no trends with flow or time. The Long King, San Jacinto, and Neches are in the humid northeast part of the study area and drain predominantly wooded watersheds. The median concentrations were generally below 1.5 mg/l, a level that should not accelerate eutrophication. The Mission River is a relatively small river in the San Antonio-Nueces coastal basin. High salt data (table 1) indicated that this river may have oilfield pollution problems, which would obscure other relations.

We could find no evidence to indicate a seasonal change in NO_3 concentrations. Streamflow is seasonal and could obscure any seasonal changes in NO_3 concentrations. Three streams, the San Jacinto, the Neches, and Long King Creek, had NO_3 concentrations that varied relatively independently of streamflow (fig. 10). The median concentration at 2-month intervals is plotted for each of these streams in figure 11.

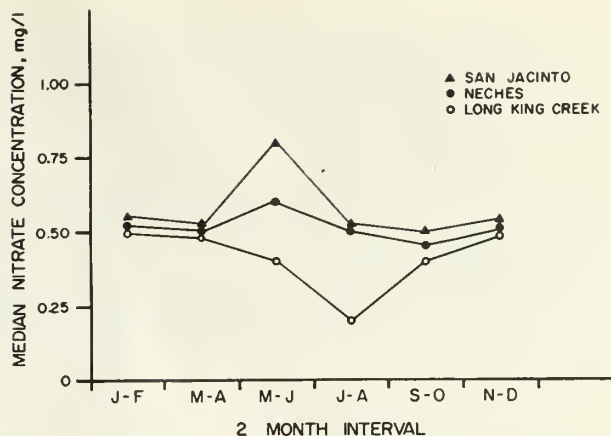


FIGURE 11.—Seasonal effect on the median nitrate concentration in three rivers.

The periodic changes in concentration were small, with no consistent trend among the three. These streams are in the humid region and had little cropland in the watershed. We could find no evidence to indicate that the NO_3 concentration in runoff was related to the amount of cropland. When the mean concentrations at 74 stations on streams originating in the study area were plotted versus the estimated percentage of cropland in the watershed above the station, the data were broadly scattered, with no trend. The range of mean NO_3 concentrations for watersheds with little cropland was 0.3 to 14.9 mg/l NO_3 and the range for watersheds with nearly all cropland was 0.6 to 16.5 mg/l. The corresponding medians of 1.2 and 1.7 would not seem to be significantly different.

In summary, the evidence did not indicate that agricultural activities were seriously degrading the stream waters. The pesticide-concentration data were extremely limited but indicated that some pesticides were found in the sediments from all streams. However, the concentrations in the water were high enough to be detected only occasionally. There seemed to be sufficient nutrients in most streams for eutrophication. The San Antonio River, which drains the city of San Antonio, had a much higher NO_3 level than any other river examined. Nitrate concentrations increased over the years in half the streams.

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